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A SYSTEM UTILIZING SOLAR ENERGY

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16. Abstract

The possibilities of using solar energy as a future energy source are discussed. A system utilizing solar energy is described and discussed. The factors necessary for a solar energy system are listed.

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A SYSTEM UTILIZING SOLAR ENERGY

Energy Department,
Energy Transport Research Office

At present, the world energy problem is at a turning point. If the world continues to consume energy at the present rate, the sources of energy — fossil fuel, in particular — will become depleted, and the environment will be adversely affected by pollution accompanying the high rate of energy consumption, leading to an uninhabitable world. Thus, the time has come for the nations of the world, especially Japan, lacking the sources of energy, to seriously consider countermeasures. /1*

These countermeasures are, first, efficient use and conservation of energy sources and, second, the development of clean sources of energy. Great emphasis is being placed on the latter, involving geothermal phenomena, tidal currents, controlled nuclear fusion reactors, and solar energy. Since the amount of geothermal and tidal current energy is limited, no great expectations can be pinned on their being potential sources of energy. Offering great hopes of an unlimited energy source is thermal energy, obtained from nuclear fusion and solar energy. However, in the former case, much remains to be done in the scientific and technical area; therefore, no speedy

*Numbers in the margins indicate pagination in the original foreign text.

solution is foreseen. Solar energy, on the other hand, is inexhaustible, pollution-free, and available at no cost. As a result, it has attracted considerable, world-wide attention, and extensive research is being conducted on the development of techniques for utilization of solar energy.

This laboratory has undertaken basic research with the aim of establishing a system for utilizing solar energy. Figure 1 shows how solar energy can be utilized on the ground for many purposes. A unique feature of this system is its capability to accommodate such relatively readily-storable energy as thermal energy and hydrogen gas energy. /2

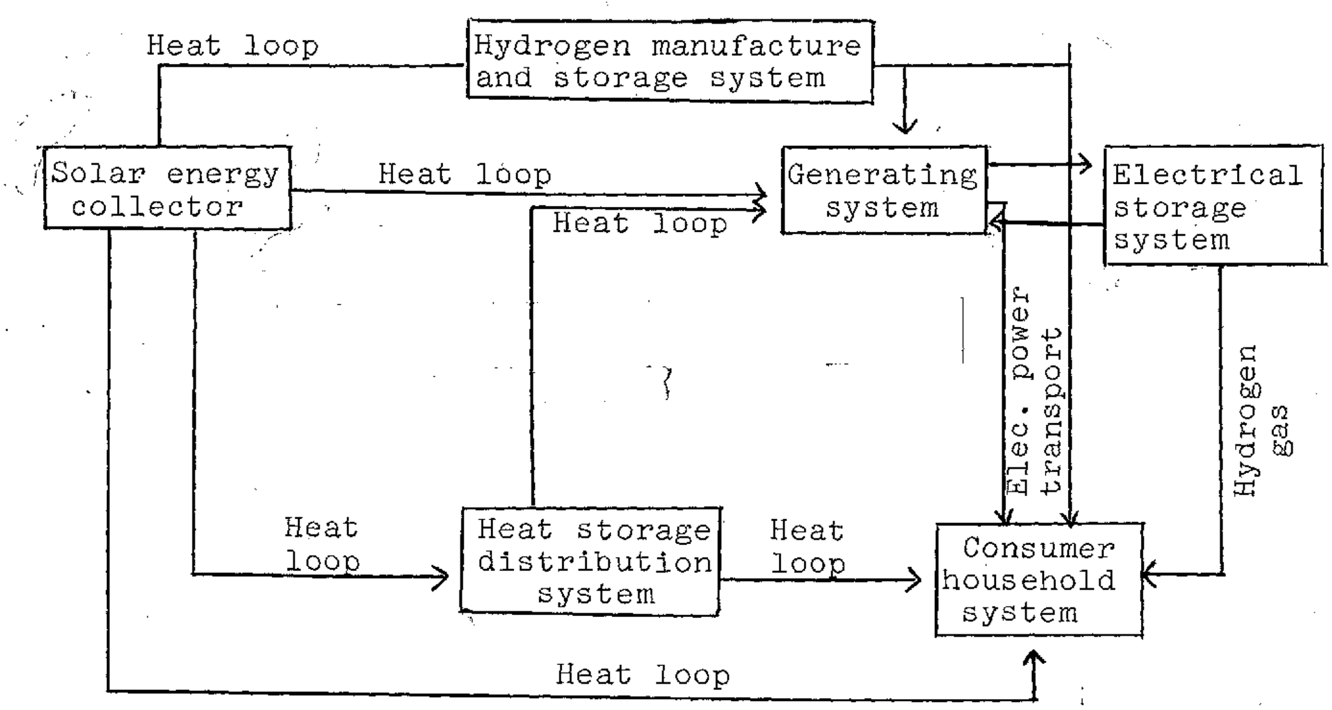


Figure 1. System utilizing solar energy

As shown in Figure 2, the integral solar energy generating system (turbine type) is comprised of a heat collecting system, transmission system, storage and distribution system, turbine system, and generating system. Solar energy, absorbed and exchanged by the heat collecting system, is carried to the heat storage and distribution system by the heat transmission loop (the heat transmission agent in

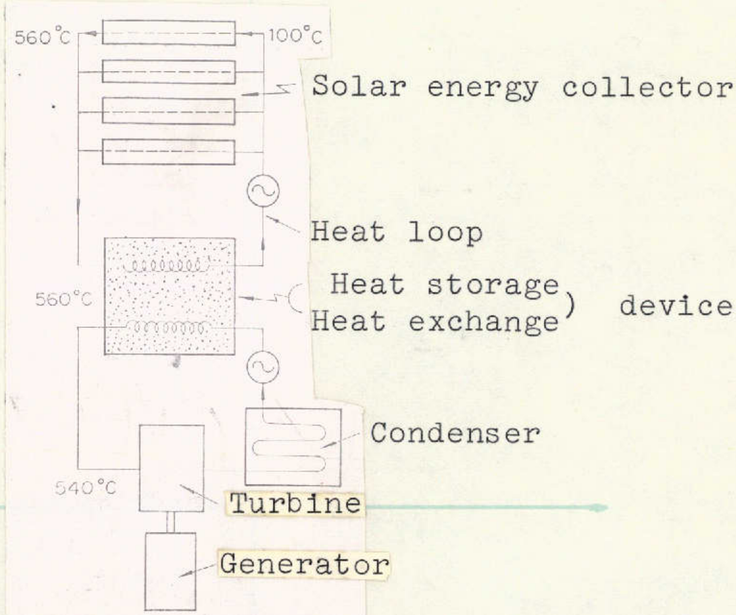


Figure 2. Sketch of solar energy generating system

the first stage is gas) where it is stored by the heat storage agent. This heat energy is later introduced to the turbine generating system via a separate heat transmission loop, and converted into electrical energy.

The photograph shows the external view of the experimental solar energy generating system. The reflecting mirror, which serves to focus the rays, measures approximately 1.2 m^2, with an absorbing capsule fitted near the focal point, as shown in the cover sheet. The converted solar energy is sealed in this vacuum capsule (a glass tube, 700 mm long and 180 mm in diameter) as high temperature heat energy by means of a selective permeating (reflective) lining. This energy, concentrated in the center of the absorbing capsule, is then captured by an absorbing body with a specially treated surface layer, and led to the heat storage exchanger by means of the heat transmission agent.

Figures 3 and 4 are examples of spectrum of the selective permeating (reflecting) lining within the absorbing capsule, and of the absorbing body. Because the solar energy has a wavelength of almost

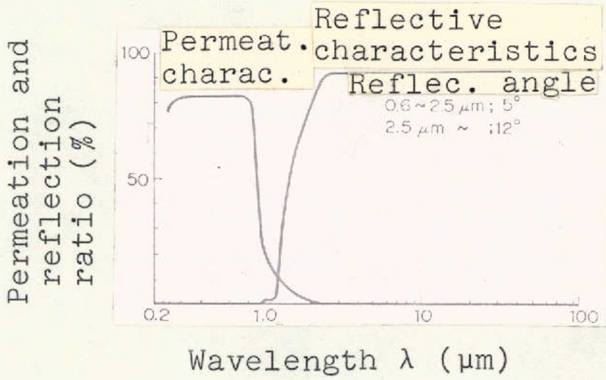


Figure 3. Light diffusion characteristics of the selective-permeating (reflecting) lining

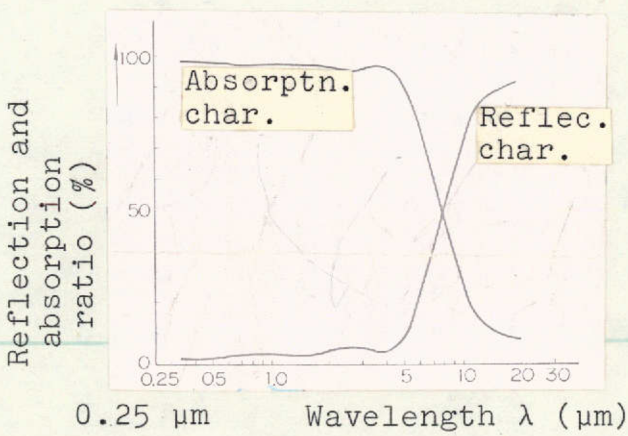
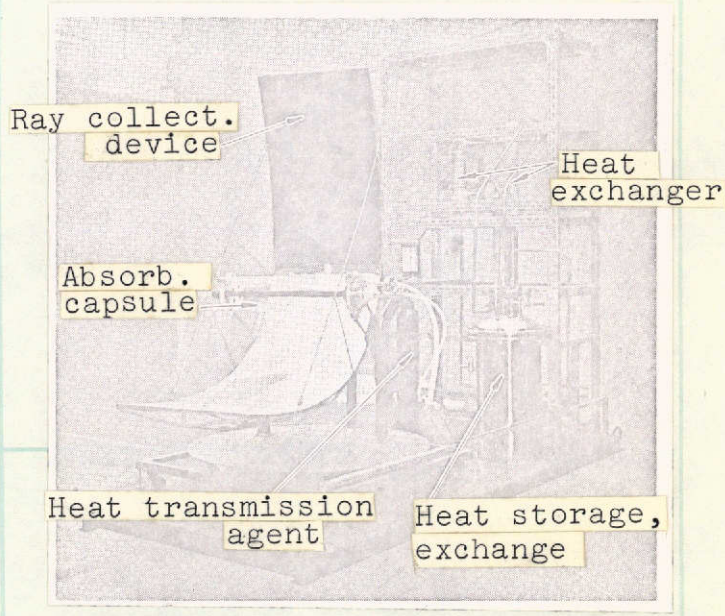


Figure 4. Selective characteristics of absorbing body



Solar energy absorber-exchanger

0.5 μm, and a high level of energy, this lining and surface permit the maximum energy to be permeated and absorbed by the absorbing body. Due to its characteristics, high temperature energy, once absorbed, will not be emitted outside the capsule. A high temperature heat pipe whose surface is treated with a selective absorbent material will probably be used in lieu of this absorbing body in the future.

Figure 5 is a cross section of the absorbing capsule showing /3
the manner of absorption of high temperature energy. Figure 6 is an infrared photograph taken of heat rays escaping from the heat generating units (set at uniform 800° C temperature) installed within a glass cylindrical tube, lined on the inside with a selective permeating (reflecting) material, and an ordinary glass cylindrical tube. As can be seen from this photograph, the reflective qualities

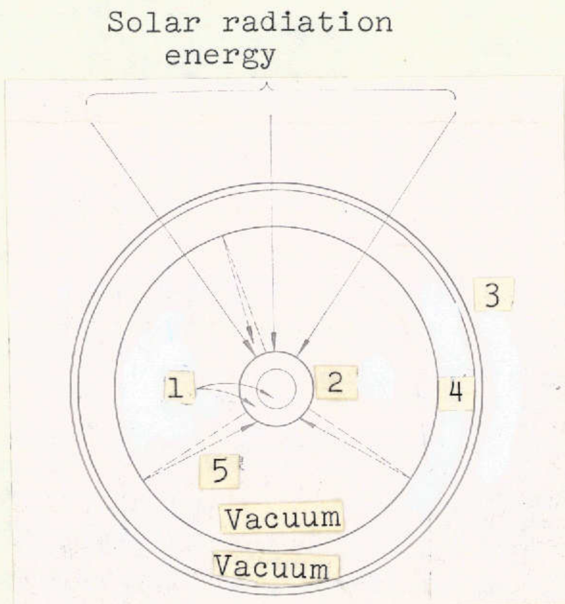
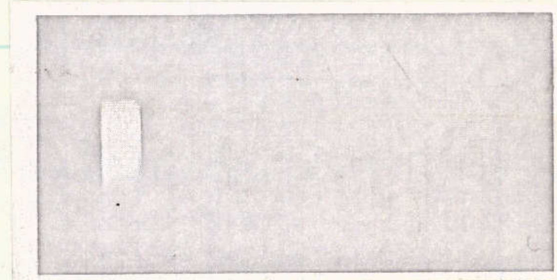


Figure 5. Cross section of solar energy absorbing capsule

1 — Heat transmission input-output-loop; 2 — absorbing body; 3 — glass cylindrical pipe; 4 — selective permeation (reflective lining) 5 — heat curve



Ordinary cylindrical tube | Glass cylindrical tube with selective permeating (reflective) lining

Figure 6. Comparison of characteristics by infrared photography (temperature of heat generating unit set at 800° C)

of the lining are superb, virtually preventing heat rays from escaping outside the cylindrical tube.

The heat storage-exchange device is an adiabatic pressurized container, has a high fusion point as a heat storage unit, and utilizes eutectic compounds having a high heat of fusion and specific heat such as alkaline metallic materials and alkaline earth materials. The heat storage energy of these materials is about 600 - 900 cal/cm^3, and the fusion point is about 150° C to 850° C.

The solar energy generating system, on which work is being done as an integral part of the solar energy utilization system, can be designed in the form of a small capacity unit for household use, or a large capacity unit for generation purposes. For example, with a solar energy absorbing device having a light collecting area of 10 m^2, a typical Japanese family can meet almost 30% of its energy needs based on a light and heat exchange efficiency of 50%. A high capacity solar energy generating plant with a light collection area of 1.3 km x 1.3 km would produce 500 mW of power per year, including the daily peak period of six hours, based on overall efficiency of 30%.

Techniques required to establish a solar energy generating system involve:

1) high efficiency absorption and exchange of solar energy;

2) high efficiency storage of high temperature thermal energy over a prolonged period;

3) high efficiency heat transfer.

In our country, it is only in recent times that research has been initiated on the development of solar rays as a source of energy, although Japan's technology in the field of solar energy utilization is on a part with the rest of the world. A wide range of technical support and extensive research and development will be required hereafter.

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